the advantages of uniformity. In the case of right-handedness it is obvious that these advantages must be great, as various tools and machines are made in conformity with the fact that nearly all persons use their hands alike; screws, for instance, having to be driven in by the rotation outward of the right hand. A left-handed man would naturally turn his wrist outwards to the left, and therefore the driving of an ordinary screw by turning the hand inward would be difficult and awkward.

In any community where there existed some left-handed men, and a building had to be erected, they would be found to be inferior workmen, and remain behind in the struggle for existence.

I understand Mr. Cockerell to say that in the case of spiral shells there may be natural environments tending to favour uniformity of shape and prolonged existence, just as in man these environments are artificial, but at the same time beneficial and tending to the same end. SAMUEL WILKS.

Grosvenor-street, May 19.

Luminous Phenomena observed on Mountains.

CONCERNING the letter of Mr. C. G. Cash, on "luminous phenomena observed on mountains," in your number of May 13 (p. 31), I do not doubt you will be informed by many readers of NATURE that they are evidently, and undoubtedly, due to St. Elmo's fire. J. M. PERNTER.

Innsbruck, University Observatory, May 21.

The Effect of Wind and Atmospheric Pressure on the Tides.

THE problem of the effect of wind and atmospheric pressure on the tides has received repeated and considerable attention from scientific as well as from practical men. Especially for the latter, *e.g.* sea captains and pilots, an acquaintance with the effects produced is of considerable importance.

The efforts and the money which all civilised nations employ in obtaining good tide-tables, prove that these are of utmost usefulness and value to navigation; and we need not be astonished at this, when we think of the necessity of a swift and safe course, especially in international trade.

The calculations of the tides in the tide-tables are principally based on astronomical influences; they indicate time and height of the tide, which may be expected from the relative position of sun, moon and earth, and generally refer to normal meteorological conditions.

In reality, those conditions differ from the normal state. Wind and atmospheric pressure are continually changing, and cause the time and the height of tide to vary in different degrees from the normal value indicated in the tide-tables.

Navigation has an interest in exact tide-tables, and, in the same way, the pilots and sea captains wish to be able to calculate the extent to which the depth of the water will be affected by meteorological influences, because it may depend on these, if it will be possible to cross a bar or shoal in a tidal river, or enter into the mouth of a tidal harbour.

So far there does not exist a formula, which allows the calculation of the correction to add to the data of the tide-tables, if the force and direction of wind and the indication of the barometer are known.

While in Germany considerable attention to the effect of wind on the tides has been paid by Hugo Lentz, Prof. Möller, Prof. Bübendey, and others, French scientific men have principally given their attention to the effect of atmospheric pressure. In the "Annuaire des marées des Côtes de France" a table is to be found, according to which a rise of one millimetre in the barometer causes a depression of the tide of 13 millimetres. The same correction can be used for all the harbours, and the seamen are advised to apply this correction. It can, however, be neglected for barometrical indications lower than the mean position, viz. 760 millimetres.

A civil engineer, E. Engelenburg, tried to calculate separately the effects of wind and atmospheric pressure for Flushing, in his article published in *De Ingenieur* (a Dutch weekly paper), No. 39, 1891. Unfortunately the records he used were not sufficient to afford a definite solution of the problem. Nevertheless, his study remains a very interesting addition to the literature on this subject.

All these investigations, however, have not led to any suitable formula by which the corrections for wind and pressure might be calculated. No wonder, therefore, that in England, the navigation-country *par excellence*, particular consideration has been paid to the said subject.

Many elaborate investigations thereon have been made by Mr. W. H. Wheeler, of Boston, who communicated the results of his study at the meeting of the British Association at Ipswich, in 1895.

Mr. Wheeler's address gave rise to the appointment of a Committee, consisting of Prof. Vernon-Harcourt, Prof. Unwin, Mr. Deacon, and Mr. Wheeler (Secretary), in order to investigate this subject, especially for the practical purpose of ascertaining whether the records of the wind and atmospheric pressure, as obtained by an observer at any particular port, might afford a trustworthy guide to pilots and mariners as to the variations to be expected in the height of the tides, from those ascertained by calculations and given in the tide-tables.

Information was asked from authorities of all the principal ports in Great Britain, and also from the Hydrographic Departments of the principal maritime ports in other countries.

The tidal records of five English ports, viz. Liverpool, Sheerness, Portsmouth, Hull and Boston, were selected for a careful examination. The results of these investigations have been presented in a report of the said Committee, drawn up by the Secretary.

In general the results obtained, both those relating to the effect of atmospheric pressure and those relating to the effect of wind, are not very satisfactory.

Nevertheless, the summary of the report contains a useful table giving the increase or decrease of tide for different forces of wind (3° to 10° Beaufort scale) per foot rise of tide.

The reason why the results are so little satisfactory, seems to me due to the method of investigation employed.

In analysing the effects of atmospheric pressure, a mistake was made by not sufficiently eliminating the effect of the wind. The latter being predominant, the effect of pressure could not be made clearly visible. Concerning the effect of wind, the principal cause of failure, I believe, is to be found in an erroneous working hypothesis, and in a wrong consideration of the influence of wind on the sea-level.

The hypothesis was, that wind blowing in the direction of the tide increases the range of tide; the high water being raised and the ebb being lowered, whilst wind blowing in a direction opposite to the tide has the contrary effect.

Considered from that standpoint the observations were separated according to the circumstance, whether the wind was blowing in the direction of the tide or contrary to it; and the results were drawn up in such a way as to show the amount of the raising or depressing of the tide, caused by the same force of wind at different ports, proportional to the mean rise of tide at those ports.

These considerations are contrary to the facts mentioned in Hugo Lentz's work, and also to the observations of the Dutch engineers on the coasts of Holland.

Those facts and observations show everywhere, that high and low water both are raised or depressed by wind, so that the range of tide is not considerably affected. They also show that the raising or depressing are not dependent on the range of tide, but depend to a great extent on the form of the coast-line, and especially on the depth of water; the effect increasing when the water is shallow.

Another point of difference is, that the most important influence is not felt when the wind is blowing in, or opposite to, the direction of the tide—as was supposed by the Committee—but, on the contrary, when the wind is blowing at right angles to the coast-line, *e.g.* perpendicular to the direction of the tide.

Hence the arrangement of the observations in the way adopted by the Committee could not but have the result that the raising and depressing of the tides partially neutralised each other.

The reasons just mentioned cause the table, according to which the variations due to wind is given per foot rise of tide, to be erroneous in principle, because the variation caused by wind is not proportional to the range of tide.

Trustworthy results can only be obtained if exact tide-tables are at our disposal; if the calculated data are compared with the observations, and the variations are arranged according to the simultaneous direction and force of the wind, and the atmospheric pressure; and last, not least, if the results are carefully arranged in such a way that each effect comes forth unaffected by the other. This principle is applied to the height and to the time of the tide on the Holland coast.

In order to get a thorough check, the calculations are made independent of each other for five series of observations as to the height, and for three series as to the time of the tide. A comparison of the results will show what degree of exactness can be obtained, and how far the obtained results can be trusted.

The said series contain—

I. (1) The height of high water at Ymuiden in 1895
(2) ,, ,, ,, ,, 1896
(3) ,, low ,, ,, 1895
(4) ,, ,, ,, ,, 1896
(5) ,, high ,, Hoek van Holland 1896
and
II. (1) The time of high water at Ymuiden in 1895
(2) ,, ,, ,, 1896
(3) ,, ,, Hoek van Holland 1896

The importance of checking is further increased because of the different methods of wind-observation.

At Hoek van Holland the indications of a self-registering apparatus were used, which gave the force in kilogrammes (kg.) per square metre. (1 kg. per square metre) = 0·205 lb. per square foot.)

At Ymuiden the direction and force were noted at 8 a.m. and 4 p.m.; the force was estimated by a scale of 6 degrees, the signification of these being as follows:—

Ymuiden scale	Signification	Equal to		
		Degrees of Beaufort scale	Pressure in kg. per square metre	Velocity in metres per second (1 m. = 1·09 yard = 3·28 feet).
1	Gentle breeze	1·9	4	5·7
2	Fresh ,,	3·3	9	8·5
3	Strong ,,	4·9	18	12·0
4	Gale	7·3	45	19·0
5	Heavy gale	—	—	—

The tidal observation has in each case been combined with the preceding meteorological observation; thus the latter, on an average, fell six hours before the moment of tidal observation.

This combination is not illogical. A special investigation at Hoek van Holland, concerning the question how much time a certain wind preceded its observed effect on the tide, in order to find the limits of this precedence, showed that the average effect on the height of tide followed the cause after a minimum of five hours (out of 17 observations), and a maximum of 6 hours (60 observations); and on the time of high water after a minimum of 4 hours (13 observations) and a maximum of 7 hours (33 observations).

The calculations for finding the effect of wind and atmospheric pressure have been made as follows.

The variations between observation and prediction (those for the height of tide after a proper correction concerning the annual variation of the height of half-tide) were arranged in groups. Each group contained the observations at a definite direction of the wind and a definite force; *e.g.* all the observations during N. wind and a force = 1° Ymuiden scale, were combined to a group N 1.

Considering that each group corresponds to a definite influence of wind, it is evident that the reciprocal differences of the variations, united in that one group, are caused by differences in atmospheric pressure.

A second supposition was, that the effect of atmospheric pressure in every group was proportional to the difference of the barometer from its normal value of 76 centimetres mercury.

Let, therefore, the wind-effect for a certain wind-group and normal barometer be x . . .

The rise of 1 centimetre barometric pressure corresponding to a depression of the sea-level of y centimetres . . .

The value of a variation $= v$ . . .

The observed barometric pressure $= 76 + b$ centimetres, then we have

$$x + by = v.$$

We have, therefore, in one group containing n observations, n equations with two unknown quantities x and y, out of which the values of x and y can be solved. This method has been applied to the groups containing ten or more variations.

The values of y thus calculated, with consideration of the number of the observations, served to deduce the effect of the directions of the wind on the value of y; this known, the groups containing less than ten variations were submitted to a correction according to the calculated value of y, and so the real value of x was obtained.

These values of x now served to deduce the following quantities:—

(1) The effect of absolute calm.
(2) ,, ,, the force of wind.
(3) ,, ,, the direction of wind.

As is known, the level of the sea at absolute calm differs from the mean annual level, because the latter is influenced by the prevailing winds.

In calculating the effect of wind the supposition was made, that for every direction the effect of definite forces is always expressed by the same proportion—*e.g.* the effect of a force 3 being double that of force 2; this proportion remaining the same at all directions of the wind.

The calculations made according to these principles showed that the effect of wind and atmospheric pressure on the tides can be represented by the following formula:—

$$C = (KR - a) + R_b(B - 76{\cdot}0),$$

in which

C is the correction in centimetres to be applied to the predicted height of high, as well as low water.

K is a coefficient depending on the force of wind.

R is a coefficient depending on the direction of wind.

$-a$ is the correction which should be applied in the case of absolute calm (when $K = 0$).

R_b is a coefficient depending on the direction of wind, although relative to atmospheric pressure.

B is the atmospheric pressure in centimetres mercury.

In order to examine the results obtained by calculating the independent series of observations, I give those *in extenso.* They have reference to conditions which have, in general, similarity enough to allow the comparison, as the following results will prove.

I. Value of K.

Force of wind according to		Calculated values of K at Ymuiden					Pressure of wind registered at Hoek van Holland, kg. per m².	Calculated value of K at Hoek van Holland, high water 1896
Estimation in degrees of the Ymuiden scale	Pressure in kg. per m².	High water		Low water		Mean of the 4 values		
		1895	1896	1895	1896			
1	4	4	4	5	3	4	0	4
2	9	10	8	11	9	9·5	0 – 5	6
3	18	21	23	20	20	21	5 – 10	12
4	45	50	38	38	45	43	10 – 20	17
5	—	71	—	75	—	73	20 – 30	34
							30 – 50	38
							50 – 70	56

II. Value of R.

Direction of wind	N.	N.N.E	N.E.	E.N.E.	E.	E.S.E	S.E.	S.S.E.	S.	S.S.W.	S.W.	W.S.W.	W.	W.N.W	N.W	N.N.W
High water, 1895 Ymuiden ...	0·6	-0·3	-1·2	-1·2	-1·1	-0·9	-0·4	0 2	0·6	0·7	0·8	1·1	1·4	1·5	1·3	0·9
„ 1896 ...	0·6	0·1	-0·7	-1·2	-1·6	-1·2	-0·4	-0·1	0·1	0·5	0·9	1·3	1·6	1·4	1·2	0·8
Low water, 1895 ...	0·8	0·1	-0·7	-1·0	-1·3	-1·0	-0·4	0·4	1·1	0·9	0·9	1·1	1·5	1·6	1·6	1·2
„ 1896 ...	0·7	0·5	0·0	-0·7	-1·4	-1·5	-1·0	-0·3	0·2	0·5	0.9	1·4	1·8	1·3	0 9	0·8
High water, 1896—Hoek van Holland	0·4	-0·3	-0·9	-1·0	-1·1	-1 4	-1·6	-0·6	0·0	0·4	0·8	1·3	1·7	1·7	1·3	0·9

III. Value of a.

High water, Ymuiden, 1895 ... $a = -3$ centimetres
„ „ 1896 ... $a = -1$ „
Low water, Ymuiden, 1895 ... $a = -8$ „
Low water Ymuiden, 1896 ... $a = -2$ centimetres
High water Hoek van Holland... 1896 ... $a = -2$ „

IV. Value of Rb.

Direction of wind	N.	N.N.E.	N.E.	E.N.E.	E	E.S E.	S.E.	S.S.E.	S.	S.S.W.	S.W.	W.S.W.	W.	W.N.W	NW	N.N.W
High water, 1895 Ymuiden ...	-12	-10	-8	-8	-7	-7	-6	-6	-6	-7	-7	-8	-11	-14	-15	-14
„ 1896 ...	-13	-13	-10	-9	-8	-9	-10	-9	-8	-7	-7	-7	-6	-9	-15	-15
Low water, 1895 ...	-11	-6	-6	-6	-1	+1	-3	-7	-8	-5	-4	-5	-8	-12	-15	-14
„ 1896 ...	-12	-14	-11	-9	-8	-6	-5	-5	-4	-4	-4	-6	-7	-9	-12	-11
High water, 1896—Hoek van Holland	-13	-14	-15	-13	-10	-10	-12	-14	-12	-9	-9	-13	-16	-17	-12	-11

In calculating the effect of wind and atmospheric pressure on the time of high water at Ymuiden in 1895 and 1896, and at Hoek van Holland in 1896, exactly the same method has been followed.

The formula by which this effect can be expressed, is the following:—

$$C_\tau = KR + R_b(B - 76{\cdot}0).$$

C_τ means the correction in minutes to be applied to the predicted time. For the rest the form of the formula is in every way equal to that for the height, except the disappearing of the term a. At absolute calm the mean time of high water, therefore, will not differ from the normal. The sign + signifies that the observed time of high water is later than the predicted, the propagation of the tide being retarded.

The following tables again give an idea of the results and the obtained degree of exactitude:—

I. Value of K.

Force of wind in degrees of the Ymuiden scale	Velocity of wind in m. per second	Calculated values of K at Ymuiden			Pressure of wind registered at Hoek van Holland, kg. per m²		Corresponding velocity of wind in m. per second	Calculated value of K at Hoek van Holland, high water 1896
		High water		Mean value		Mean value		
		1895	1896					
1	5·7	3	6	4^{6}	0	0	2	1
2	8·5	6	5	5^{9}	0-5	3	4·9	4·5
3	12·0	9	9	8^{8}	5-10	7	7·5	7
					10-20	14	10·6	10
					20-30	24	13·9	13
					30-50	38	17·4	20

As an explanation, it may be mentioned that the velocity of wind being v metres per second, the pressure can be represented by $k = \frac{1}{8}v^2$ (k being expressed in kg. per m²); and the pressure k being known the velocity $v = \sqrt{8k}$.

II. Value of R.

Direction of wind	N.	N.N.E.	N.E.	E.N.E.	E.	E.S.E.	S.E.	S.S.E.	S.	S.S.W.	S.W.	W.S.W	W.	W.N.W	N.W	N.N.W
Ymuiden, 1895	$0{\cdot}4^{5}$	1·1	1·6	0·8	-0·4	-1·2	-1·1	-1·0	-1·3	-1·1	-0·9	-0·7	-0·2	0·1	0·3	$0{\cdot}4^{5}$
„ 1896	1·5	1·6	1·3	0·5	-0·2	-0·7	-1·1	-1·1	-0·9	-0·7	-0·6	-0·4	-0·1	0·5	1·1	1·3
Hoek van Holland, 1896	1·4	1·6	1·1	0·6	0·0	-0·5	-0·7	-1·5	-1·8	-1·4	-1·0	-0·7	-0·5	0·1	0·5	0·9

III. Value of R_b.

Direction of wind	N.	N.N.E.	N.E.	E.N.E.	E.	E S.E.	S.E.	S.S.E.	S.	S.S.W.	S.W.	W.S.W	W.	W.N.W	N.W	N.N.W
Ymuiden, 1895	1	-1	0	3	4	3	4	5	4	3	3^{5}	4^{5}	7	8	6	2
„ 1896	2	2	1	3	5	6	5	4	4	6	7	6	5	3	-1	0
Hoek van Holland, 1896	-2	-3	1	3	4	5	5	6	7	7	6	5	6	7	5	2

The given data may serve to show the value of the results.

We see that the correction for the height of high water, as well as of low water, at Ymuiden and Hoek van Holland, can be expressed by one formula with a sufficient degree of exactitude for practical use.

Herewith the proof is given that the wind and atmospheric pressure do not considerably change the range of tide, but affect the high and the low water in the same way, both being raised or depressed.

The value of a at low water seems rather larger than at high water; thus on an average the absolute calm-level at low water is 5 centimetres lower than the mean low water, and at high water 2 centimetres lower than the normal. In practice this difference of 3 centimetres may fairly be neglected; for the study of the phenomena, however, they are important, because they show that the raising of the level, caused on the Holland coast by the prevailing western winds, is rather more considerable at low water than at high water. The reason of this is the greater depth of water at high water-level.

The tables show very clearly that the influence of atmospheric pressure on the height of the tides is not the same for the different directions of the wind, but is the greatest during northern winds, the feeblest during southern winds; the proportion often being much more considerable than we might expect from the proportion of the densities of mercury and sea-water.

I think it probable that in this proportional factor, the character of wind is comprehended—that is to say, that at a certain atmospheric pressure the same observed wind may be more local than at another barometric pressure; in the latter case the wind, for instance, reigning over a more considerable part of the North Sea, and thus having a greater effect on the height of the sea-level.

Very remarkable is the evident and regular influence of atmospheric pressure on the time of high water, which at first consideration one would not expect. High barometer retards the time of high water.

The values of R show clearly that the sea winds raise the level of the sea, and off-shore winds cause a depression. North and south winds act as sea winds; the neutral line lies N.N.E. and S.S.E. The greatest rise is more considerable than the greatest depression, the former being caused by W.–W.N.W. wind, the latter by E.–E.S.E. wind.

The effect of wind on the time of high water is not in phase with that on height, but differs about 90° with it.

The tables indicate that southern winds, which have the same direction as the tidal wave, advance the moment of high water, whilst northern winds retard this moment. The most important retardation is observed during N.N.E.–N.E. wind; the most important advance during southern winds; the neutral line is between E.N.E. and E. and between W. and W.N.W.

The most remarkable result, brought out with surprising clearness, seems to have the character of a general law of nature (which, however, should be affirmed with perfect evidence by comparing the obtained results with those on other points observation), and is the following:—

That the raising or depressing is proportional to the pressure of wind, and that the advance or retardation in time is proportional to the velocity of wind.

It would be highly interesting if the same kind of investigation could be applied to the English North Sea coast, in order to see whether the influence of wind, as found for the Holland coast, is local, and therefore opposite to the results to be obtained at the English side; or if the results are the same, thereby indicating the influence to dominate the whole North Sea.

A special investigation as to whether a wind, continually blowing, increases or decreases the effect on the high water-level, did not give a definite rule. In general there seemed little difference in height between the first and the second high water for the same conditions of wind.

Strong off-shore winds seem to influence the second, and, principally the third and following high water-tide less than the first; so that the long duration seems to weaken the effect of off-shore winds.

Preceding formulæ now permit us to give a formula for practical use. This formula is:

(1) For the height of high water and low water at Ymuiden and Hoek van Holland,

$$C = KR - 3 - R_b(B - 76{\cdot}0),$$

expressed in centimetres.

(2) For the time of high water at Ymuiden and Hoek van Holland,

$$C_\tau = K_\tau R_\tau + R_{b\tau}(B - 76{\cdot}0),$$

expressed in minutes.

These formulæ give, as for the sign, the correction to be applied to the height, and the time predicted in the tide-tables.

The value of the coefficients are given in the following tables:—

Direction of wind		N.	N.N.E.	N.E.	E.N.E.	E.	E.S.E.	S.E.	S.S.E.	S.	S.S.W.	S.W.	W.S.W	W.	W.N.W	N.W	N.N.W
Values of	R ...	0·6	0	−0·7	−1·0	−1·3	−1·2	−0·8	−0·1	0·4	0·6	0·9	1·2	1·6	1·5	1·3	0·9
	R_b ...	12	11	10	9	7	6	7	8	8	6	6	8	10	12	14	13
	R_τ ...	1·1	1·4	1·3	0·6	−0·2	−0·8	−1·0	−1·2	−1·3	−1·1	−0·8	−0·6	−0·3	0·2	0·6	0·9
	$R_{b\tau}$ ...	0	0	1	3	4	5	5	5	5	5	5	5	6	6	3	1

The way in which the values of K and K_τ are to be chosen, depend on the way of observing the force of the wind. The mentioned relation between pressure, velocity of the wind, and the value of K and K_τ permits the choice of the proper value of the latter, pressure or velocity of wind being given.

If the force is estimated in degrees of the Beaufort scale, as is usual among mariners, we may choose K and K_τ according to the following table:—

Degrees of Beaufort scale	K=	K_τ=
0	0·4	1·5
1	2	3
2	6	4·5
3	10	6·5
4	16	8
5	25	10
6	36	12
7	50	15
8	70	18
9	90	21
10	110	25

The mean age of the effect of wind and atmospheric pressure in the calculation being considered as six hours, which is not far from the truth, we may consider that the prediction of the next high water in general ought to be corrected with the observation of wind and barometer at about the preceding low water; a case which will often occur in practice, when vessels wait for the rising water to enter into the harbour.

Suppose a sea captain approaches a harbour entrance, and wishes to determine the correction for the next high water, in order to apply it to the predicted height of the tide-table. He therefore observes direction and force of the wind, and also the state of the barometer, and finds, for instance:—

Direction	N.
Force	7 Beaufort.
Barometer	77·5 centimetres.

The values to be found in the given tables are:—

$$K = 50 \qquad R = 0{\cdot}6 \qquad R_b = 12.$$

The correction $C = (50 \times 0{\cdot}6) - 3 - 12(77{\cdot}5 - 76{\cdot}0) = 30 - 3 - 18 = 9$ centimetres.

Thus the high water-level will be raised by 9 centimetres above the predicted height of the tide-table.

It will be easy for English mariners to change these formulæ into others, expressed in feet and inches instead of in centimetres.

At the end of these deductions it will, perhaps, not be out of place to state that the calculations give an approximation, and that no absolute reliance can be placed on the formula.

The effects to which the level of the sea is subject are so many and so varied, and there may be in operation agencies acting over a distant area which cannot be discovered by local observation, or which may have been in operation on previous days, that it will never be possible to give a correction of mathematical exactitude.

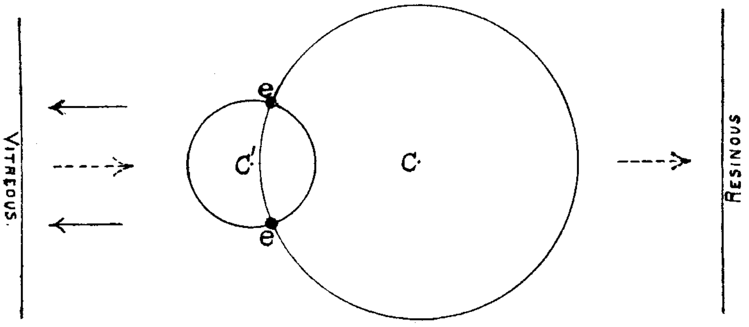
But every indication which approaches truth, and which increases our knowledge, is useful, and in this light the formulæ given should be considered. F. L. Ortt.

The Hague, Holland.

CONTACT ELECTRICITY AND ELECTROLYSIS ACCORDING TO FATHER BOSCOVICH.

Yesterday evening, in the Royal Institution, I spoke of an ideal one-fluid electricity subject to attractions of solid substance, to account for contact electricity of metals; and I said that before the end of our meeting I might speak of it further and might have to reverse the conventional language I was using as to positive and negative, and call resinous electricity positive, and vitreous negative. My allotted hour was woefully overpast, and half an hour more gone, before I could return to the subject; and I felt bound to stop. What I wished to say may be said in the columns of Nature in fewer words than I could have found, to make it intelligible, last night.

Configuration Before Action Of Electrolytic Force



Electrolytic Force Shown By Arrows.

Varley's fundamental discovery of the kathode torrent, splendidly confirmed and extended by Crookes, seems to me to necessitate the conclusion that resinous electricity, not vitreous, is *the electric fluid*, if we are to have a one-fluid theory of electricity. Mathematical reasons, to which I can only refer without explanation at present, prove that if resinous electricity is a continuous homogeneous liquid, it must, in order to produce the phenomena of contact-electricity which you have seen this evening, be endowed with a cohesional quality such as that shown by water on a red-hot metal, or mercury on any solid other than a metal amalgamated by it. It is just conceivable, though it does not at present seem to me very probable, that this idea may deserve careful consideration. I leave it, however, for the present, and prefer to consider an atomic theory of electricity foreseen as worthy of thought by Faraday and Clerk Maxwell, very definitely proposed by Helmholtz in his last lecture to the Royal Institution, and largely accepted by present-day theoretical workers and teachers. Indeed, Faraday's law of electro-chemical equivalence seems to necessitate something atomic in electricity, and to justify the very modern name *electron*. The older, and at present even more popular, name *ion* given sixty years ago by Faraday, suggests a convenient modification of it, *electrion*, to denote an atom of resinous electricity. And now, adopting the essentials of Aepinus' theory, and dealing with it according to the doctrine of Father Boscovich, each atom of ponderable matter is an electron of vitreous electricity; which, with a neutralising electrion of resinous electricity close to it, produces a resulting force on every distant electron and electrion which varies inversely as the cube of the distance, and is in the direction determined according to the well-known requisite application of the parallelogram of forces.

In a solid metal the ponderable atoms must exert such other mutual forces, compounded with the electric forces, that the assemblage in equilibrium shall have the crystalline configuration, and the elasticity-moduluses, of the metal. The electrions must be perfectly mobile among the ponderable atoms, subject only to the condition that the electric attraction ceases to increase according to the inverse square of the distance and becomes zero (or, perhaps, strong repulsion) when the distance is diminished below some definite limit. For simplicity we may arbitrarily assume the following conditions:

(1) Each electrion is a point-atom of resinous electricity and repels every other electrion with a force varying inversely as the square of the distance between them.

(2) Each electrion is attracted by each ponderable atom with a force which varies inversely as the square of its distance from the centre of the ponderable atom when the distance exceeds a certain limit r and is zero when the distance is less than r.

(3) The shortest distance between two centres of ponderable atoms need not be limited to be $>2r$: it may be whatever we find convenient for the structure and properties to be realised. It will be $>2r$ in an insulating solid and $<2r$ in a conductor.

Two pieces of metal, M, M′, each constituted as I have now explained, will behave in respect to contact-electricity just as two pieces of metal behave in a perfect vacuum. For example, if $r>r'$, M will behave to M′ as zinc behaves to copper.

To illustrate electrolysis, consider an ideal case of a detached compound zinc-copper atom, composed of two single atoms with their centres at C, C′; and two electrions *e*, *e* which must, for equilibrium, be in the positions shown in the diagram, if r, r' be of such magnitudes as the radii of the circles showing the shortest distances to which C and C′ attract electrions. Let now electrified bodies at great distances (such as the vitreously and resinously electrified plates indicated in the diagram) act in the manner indicated by the dotted arrows relatively to the ponderable atoms, and the full arrows relatively to the electrions. The ponderable atom C will be drawn away to the right by the electric force on itself: and the ponderable atom C′ will be dragged away to the left by the two electrions overcoming the rightward force which itself experiences in virtue of the electric field. Lastly, to take a real case, the electrolysis of copper-sulphate, let C′ be the centre of an atom of copper in combination with oxysulphion (SO_4), not shown in the diagram; with, in all, six electrions. The copper atom C′ will be drawn away to the right, with no electrion attached to it: and the oxysulphion will be pushed and dragged to the left by the excess